Comments received from David Batts, King County
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All text	Except for very small text (e.g. the phone book) and larger section headings (for visual distinction), serif fonts are generally preferred for readability.
Text references to and from other guidance documents	Guidance by reference is problematic. As it now stands, the draft 2012 Stormwater Management Manual for Western Washington (SWMMWW) points to this Draft LID Manual. e.g., SWMMWW Vol I says in two places (3.1.1 (analysis of site conditions) and 3.1.2 (preliminary site layout): *This section will be updated to be complementary with Site Assessment procedures described in the updated Low Impact Development Technical Guidance Manual for Puget Sound.* The Draft LID Manual suffers the same problem. The cover WSU letter says; *"What is not included for your review:* *Chapter 7 which is Ecology's design and flow control guidance. This is in Appendix III-C of the SWMMWW Volume 3. Once comments are received and Ecology updates that section we will include it in the LID Manual.* Then, e.g. on pg 17 of the Draft LID Manual, there are references to two documents external to the Manual: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm and the Rain Garden Handbook for Western Washington Homeowners The putative benefit to this approach – reference to external documents – is that referenced guidance is ostensibly the most current available. However, there are several problems with this approach. Noted problems include: - Collectively, these are promoted as guidance for compliance with the NPDES Municipal Stormwater Permit. What mechanism is there for regulatory review

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	to be sure that following the collective guidance will in fact ensure permit compliance? - As a collection of referenced material, this presents a moving target to Permittees and development applicants affected by the permit. - Publication of external documents may cease, and the documents become no longer available. While this seems unlikely for this Manual, a case in point is where the 2005 SMMWW points to Ecology publication 94-038, which is no longer available in any form – hard copy or electronic. - Web pages (e.g. referenced link above) are notorious for changing both URL (location) and content, so they make poor references. While we can provide review of technical details and some overriding concerns, the fragmentation and interconnectedness of applicable sections of both manuals relevant to Permit compliance – along with incomplete or draft status of some of these sections – impairs ability to piece together a clear roadmap as to how each is to be used in support of specifics of the Permit. At least for this LID Manual, it would be helpful if each section referred to by the SWMMWW is flagged as such in the LID Manual itself.
All text	Can't find a References section. In the absence of full citations in a References section, by and large can't assess the applicability/relevance of citations in this review.
All graphics	Please include citations for graphics taken from other publications, if any; include data sources for graphs generated for use in this LID Manual; include credits and dates for photos and graphic drawings.
Misc. graphics	Are missing, so we cannot review them. Absence is noted in the Draft LID Manual cover letter. Response here is simply to note that as a problem in review.
Compost specification	In the absence of solicitation for review, following are some review comments we submitted with our SWMMWW review: Compost for Use for Stormwater Treatment Media

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	The only compost standard in Washington is currently WAC 173- 350-220. We are not questioning use of that standard for compost used for general landscaping. However, we are concerned about the standard with respect to compost use for stormwater treatment BMP media. The compost quality criteria are very limited in the list of risk parameters – nine heavy metals, pH, bacteria, and sharps. The allowable metals levels seem quite high. The absence of standards for any other pollutants in compost means there is a large information gap with respect to risk from other pollutants when using compost. According to Mikula et al. (2007),"... it has been shown in past filter work that the media can be a source of pollutants either due to the release of previously-trapped compounds or of compounds contained in the media itself. It has been well documented that small concentration gradients between the media and the pollutants in the water results in weak removals, and that when media concentrations of a pollutant are greater than those in the passing water, negative removals occur". There is also some literature showing net export of some metals from some compost/mixtures. In order to find that compost even marginally meeting WAC 173-530-220 heavy metals criteria is as effective at removal of those same metals from stormwater as is compost containing much lower heavy metal pre-loading requires testing that to the best of our knowledge has not been done. It seems a reasonable presumption that considering compost media filtration, with e.g. a cartridge filter system, eventually the cartridge will become loaded, and that at the very least it makes sense to start with a filter with as little pollutant preloading as possible. Any monitoring of bioretention / rain garden systems should include measurement of pollutant concentrations in the compost and the media in addition to influent and effluent concentrations. Further, we need long term – i.e. decades long monitoring. And we need monitoring at a number of geographically/spatially diverse sites representing a variety of land uses local climates, and bioretention media sources.
Roofing	Roofing is given somewhat more scrutiny in the Draft LID Manual than in the SWMMWW, which says only, "Metal roofs are also considered to be PGIS unless they are coated with an inert, non-leachable material (e.g., baked-on enamel coating)".

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	(More on that condition later). while the LID Manual is more cautionary regarding roofing, there is a fairly compelling amount of literature that offers weight to the notion that roofing systems (including gutters and downspouts) should be considered pollution-generating as a class, and this should be considered with regard to treatment required prior to any use, infiltration, or discharge. Comments submitted in our review of Ecology's SWMMWW follow: There is a substantial body of literature indicating potential for a wide variety of roofing materials to leach, weather, and convey a wide array of pollutants at levels of concern for both surface water and groundwater. Recent related reports from Ecology indicate that zinc is not the only chemical of concern from roof runoff ((Roberts et al. 2011), (Norton et al. 2011)). Weight of evidence from these and other readily available research literature – some of which is likely referenced by Ecology (*ibid*), demonstrates that roofing besides zinc, copper, and lead (which are of obvious concern) have been found to release pollutants at levels of concern: ((Ammann et al. 2003), (Bucheli et al. 1998a), (Bucheli et al. 1998b), (Chang et al. 2004), (Clark et al. 2008a), (Clark et al. 2008b), (DeBusk and Hunt 2009), (Dietz 2007), (Mason et al. 1999), (Nicholson et al. 2010), (Schueler 1994), (Van Metre and Mahler 2003), (Vialle 2011a), (Vialle et al. 2011b), (Zobrist et al. 2000)). Pollution-generating roofing materials include but are not limited to wood shingle, plywood with tar paper, built-up, rock and tar, composition asphalt shingle, concrete tile, ceramic, polyester, and terra cotta. Pollutants of concern at levels commensurate to or even exceeding levels found in 'typical' PGIS stormwater, but discharging from roofing, include but are not limited to heavy metals, PAHs, organic pesticides, organic halogens, phthalates, and nutrients. In any given situation, some proportion of each pollutant present is intrinsic, and some may be extrinsic. Intrinsic sources of these substances from roofing include but are not limited to heavy metals from bare metal in roofing or as 'moss strips', possibly as a leachable catalyst for e.g. EPDM membrane roofing, or entrained in granular, powder, or metal salt form as moss killer or for rot resistance; and organic chemicals used for moss killer, rot resistance, other

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	pesticides/herbicides, and/or possibly fire retardants. Ironically, 'green roof' substructure may be treated with leachable toxic materials for rot-resistance, intentions notwithstanding, owners may apply fertilizer and/or pesticides to green roofs, and even the soil layer itself may leach some additional pollutant; so while green roofs are expected to provide some hydraulic benefit, there may be unintended consequence of additional pollutants in the discharge. The SWMMWW allows that metal roofs "coated with an inert, nonleachable material (e.g., baked-on enamel coating)," are non-pollution generating, but without clear guidance on what constitutes 'inert', the coating itself may leach harmful substances. e.g. in the case of "baked on enamel", this is likely to actually be a baked on 'powder coat' plastic coating, which may contain heavy metals for pigment and/or e.g. UV stabilization, and may leach e.g. phthalates or other plastic components, rather than vitreous (porcelain) enamel, which is brittle. Whatever its own pollution-generation potential, roofing may also convey pollutants from dry deposition or via precipitation. Extrinsic pollutants include but are not limited to heavy metals, PAHs, pesticides, halogenated organic compounds, nutrients, bacteria, viruses, soot, and TSS. Which pollutants are most prevalent is likely to be somewhat land-use dependent, but there will be some overlap and as always – variability. Further, an obvious source of heavy metals in the Pacific Northwest is the use of metal strips and granular or liquid moss killer applied to roofs by homeowners and contractors. Last but not least, flashing, gutters and downspouts must be considered part of the roofing system, and their pollution-generating potential factored in. Drainage materials of concern include zinc/galvanized, copper, lead (e.g. flashing for tile/slate roofs), and plastics which may contain heavy metals and/or leach e.g. phthalates. There is a well documented case of deck-drainage downspouts on the SR-520 bridge causing high zinc leachate levels in the discharge, while bridge runoff itself was relatively low in zinc concentration. There is no reason not to suspect that the same could occur with zinc and copper roof gutters and drains. Plastic materials may not get a free ride either; heavy metals are used for color and stabilization of some plastics, and may leach out. Further, some plastic compounds

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	may leach, e.g. phthalates or bisphenol A. The Draft LID Manual notes: "The National Sanitation Foundation (NSF) certifies products for rainwater collection systems. Products meeting NSF protocol P151 are certified for drinking water system use and do not contribute contaminants at levels greater than specified in the USEPA Drinking Water Regulations and Health Advisories (Stuart, 2001)." Assuming these certified products do not leach or erode toxic materials does not ensure that runoff will meet drinking water standards for any contaminants that arrive by dry deposition and/or contained in precipitation; e.g. bacteria, PAHs, and mercury. Further, drinking water standards and criteria for aquatic protection differ, and meeting one standard does not ensure meeting the other. e.g. the GWS for copper and zinc are 1000 and 5000 ppb (total metals) respectively, whereas the acute FWS are ~ 5 and 35 ppb respectively (at 25 mg/L hardness).
Cation exchange capacity (CEC)	May have missed it, but didn't see a test method recommended. Our review comments for the SWMMWW follow, and are relevant here as well: Ecology should revisit cation exchange capacity (CEC) analytical method, and re-evaluate whether method 9081 is suitable. (Cornell 2007a), (Cornell 2007b) suggests that the stock method may overestimate CEC when analyzing acidic soils. EPA 9081 itself says at the outset: "The method of cation-exchange capacity by summation (Chapman, 1965, p. 900; see Paragraph 10.1) should be employed for distinctly acid soils." A likely scenario is that Applicants will simply send soil samples to the lab and ask for method 9081, without pointing out to the lab that western WA precipitation is acidic, and soils are often acidic. It would seem prudent to make it clear that the method should be by summation, not the sodium acetate protocol of 9081.
De-icing salts	Recommend addressing the effect of pavement de-icing salts where runoff may occur into bioretention facilities or rain gardens. Following are comments we submitted in our review of the SWMMWW: The SWMMWW and the LID Manual should both consider

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	what happens to trapped pollutants when a facility or BMP is exposed to salt in runoff from winter deicing, and effects on soils and metals entrained in soils ((Bäckström et al. 2004), (Granato et al. 1995), (Howard and Sova 1993), (Nelson et al. 2009), (Norrström 2005), (Oberts et al. 2000)); mechanisms include cation exchange, metal-chloride complex formation, increasing solubility of metals, and colloid mobilization/dispersion; pH change has also been noted. First flush toxicity has been shown to increase. Oberts et al. (*ibid*) notes that the picture is complicated because" Sodium easily exchanges with Ca and Mg in soils, destroying soil structure and mobilizing organic matter", which can then increase mobilization of metals complexed to organic matter. While complexation may decrease bioavailability to fish, benthos feeding off sediment may still be affected; and complexation of mobilized metals is un-protective from a drinking water point of view.
pg 1	"Native forests of the Puget Sound lowlands . . ." Excludes consideration of prairies – including room for discussion of what causes prairies, and if/how forest and prairie soils differ. Without defining the bounds of "lowlands", seems to exclude a considerable amount of area subject to development in Puget Sound and more broadly Western Washington.
pg 1	Inclusion of hydrologic information from Great Britain without a citation-supported argument that it is equivalent to Puget Sound climatically and with respect to topography and soil geology seems questionable. Values from British Columbia could also use support.
pg 1	Percent ET attributed to "the rainy season" and "the winter months" seem high. If we find that British Columbia evapotranspiration values are reasonably comparable to our area, Jassal et al. (2009) found ~ 26%, 25%, and 19% *annual* ET respectively for Douglas fir stands 58, 19, and 7 years of age; location was the east coast of Vancouver Island. (Moore and Wondzell 2005) say, "On an annual or seasonal basis, interception loss from conifer forests in the Pacific Northwest generally represents about 10 to 30 percent of total rainfall, depending on canopy characteristics and climatic conditions. (NOAA NCDC 2008) indicates that in the Seattle area, ET in

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	January is ~ 0.1 x July ET. While pan evaporation does not have the same dynamics as ET, and only two papers are cited here (for want of time), there seems to be sufficient evidence to suggest that a more in-depth literature review would be prudent. (*Irony noted with respect to critique elsewhere regarding web citations; reference is a link to a USGS web site; web linkage is discouraged. Have saved the web page as a PDF in case the link or content goes away*)
graphic 1-1	Per comments above, questioning the 40-50% evapotranspiration figure, and recommend a more in-depth literature review. The drawing seems overly simplistic with regard to representation of hydric soils and high groundwater conditions. The <1% surface runoff note in the figure is not supported directly by preceding narrative text (w. citation).
graphic 1-3	None of the values in the figure are supported by preceding narrative text (w. citation).
pg 1	The phrase "Typically, 2 to 4 feet of soil, high in organic material and biologically active near the surface, overlays the subsurface geology . . "; seems ambiguous with regard to soil usually being described in multiple horizons, and especially with regard to the known extreme heterogeneity of soils across Western Washington. This seems important, because an overly simplistic view does not inform us as to the difficulties and attention to local detail that needs to be paid to dispersive and infiltrative LID strategies.
pg 1	RE: "Shallow subsurface flow (interflow) moves slowly down slope or down gradient over many hours, days, or weeks through these upper soil layers." Is this true in advance gravel outwash as well? As per the preceding comment, the statement seems overly simplistic, and may give short shrift to caution with regard to groundwater quality protection.
pg 17	RE: "A soils report prepared by a licensed geotechnical engineer, licensed engineering geologist or project proponent" Inclusion of 'project proponent' as an alternative seems like an open invitation not to hire a licensed professional for the evaluation, and begs the question of how to ensure adequate

<table>
<tr><th>Page # or Graphic #</th><th>Comment</th></tr>
<tr><td></td><td>soil characterization absent professional assessment.</td></tr>
<tr><td>pg 17</td><td>Soil surveys are allowed for characterizing underlying soils. Puget sound soils are notoriously heterogeneous, and soils surveys are not detailed enough to ensure correct characterization of site soils – especially for smaller sites, but no less important for dispersion and infiltration areas at larger sites. Correct characterization is crucial on one hand with regard to minimum Ksat ensuring infiltration, and on the other hand with regard to both Ksat and soil geochemistry and biotic potential with regard to groundwater protection. Hathorn et al. (1995) put it well, saying:

"The proper choice of soils to achieve both the hydraulic and pollutant removal demands is difficult to attain because these objectives are at odds with each other."

The same idea is also conveyed in a broader discussion of "Conflicting Functions and Processes by Ellis, (2000).

Knowing the nature of local soil with a high degree of certainty is necessary for appropriate spacing of in-situ infiltration tests and application of dispersive and infiltrative LID techniques.</td></tr>
<tr><td>pg 17</td><td>As noted in broad-coverage ('All text') comments at the beginning of this table, reference to a web page (http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm) is ill advised, as the location (URL) and/or content of this page may change in a relatively short period of time, rendering it inaccessible or altering its usefulness.</td></tr>
<tr><td>pg 17</td><td>RE: Determining 1 foot depth to groundwater, analysis performed "during the winter season":

- 'Depth to groundwater' is mentioned generically. The term 'depth to seasonal high groundwater should be used.

- "Winter season" is not an adequate descriptor to meet the intent of determining the seasonal high groundwater level. Testing done during a relatively dry year or even a normal rainfall year will not predict maximum groundwater level during a high rain fall year.

According to USGS:

". . . while streamflow responds fairly quickly to precipitation as expected, changes in ground-water</td></tr>
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	level often lag in response time. Even in months when precipitation is above normal, the ground-water level does not always rise back up to normal. This indicates that ground-water responds more slowly than surface-water to precipitation, and that the relationship between precipitation, ground-water and surface-water is complex." (USGS 2003) While that note is with regard to a specific site in ME – able to obtain quickly for this review – it is reasonable to assume that the caveats are applicable more generally to precipitation-groundwater interactions elsewhere, including this state. This recommends need for more robust and prolonged evaluation of groundwater level, e.g. but not limited to long-term well or pit monitoring, with consideration for precipitation depth and pattern during monitoring. - 1 foot depth is not enough – at the very least because there is no margin of safety for year-to-year level variation caused by year-to-year differences in precipitation totals and patterns. - With regard to depth to groundwater, in relation to groundwater protection, we noted in our comments on the SWMMWW: "We are concerned that depth to groundwater may be insufficient. As commented for Vol. 1, we believe a full literature search on this subject is warranted (please see that full commentary). Pending that, we do not believe it is appropriate to allow a minimum separation of 1 foot – if for no other reason, then at least because this provides virtually no margin of safety – and no less than 3 feet should be used" (*this was specific to less than 5000 sq ft discharge to bioretention*). "For larger contributing areas depth should be greater; i.e., no less than 10 feet, per Hathorn et al., (1995)". (Keswick and Gerba 1980) report finding viruses and even bacteria at greater depths (review report), indicating that even 3 to 10 feet may not be protective in some instances.
pg 19	Same comments as immediately preceding for pg 17, with regard to depth to groundwater and its determination; there is some guidance – although still not extensive enough – for

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	groundwater depth assessment. Guidance should include considerations for precipitation during the monitoring year compared to normal and high rainfall years, with some margin of safety in the calculation. This is covered to some extent later on pg 25, under 'Soil stratigraphy', but should be also mentioned on pg 19. Also in this case, 5 feet depth to seasonal high groundwater is mentioned; and again, as noted above, this may not be a protective enough depth; and we recommend a depth to groundwater of no less than 10 feet as prudent, pending further research.
pp 21-25 Infiltration Tests	We believe that in-situ infiltration tests will be most representative if done under naturally saturated conditions. They should also not be done until site development and construction is complete. Good intentions notwithstanding, unintentional compaction is a real threat, and as noted in the LID manual, can have a profound deleterious effect on infiltration rates.
pg 116	RE: Cation Exchange Capacity (CEC) must be ≥ 5 milliequivalents/100 g dry soil. This value is widely disseminated but we have yet to see a scientific or engineering justification in any publication, explaining the relationship between this value as a minimum requirement for cation pollutant removal ability or longevity.
pg 138	RE: "Estimates (modeling) from lab and field research suggest that metal accumulation would not present an environmental concern for at least 20 years in bioretention systems (Davis et al., 2003)." Absent a reference section with the full citation, we can find a similar 20 year claim in a paper by Davis, A.P., et al., 2003. If this is the same paper, the actual quote is: "After 20 years, cadmium, lead, and zinc accumulations reach or exceed regulatory limits for biosolids application (U.S. EPA, 1993). The time required for metal accumulations to reach these limits are 20, 77, 16, and 16 years for cadmium, copper, lead, and zinc, respectively. Lead and zinc are the limiting metals and, at the regulated values, metal levels may present a health risk. Metal

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	buildup should be halted and facility reconstruction should be addressed." If this is the cited source of the 20-year value, the environmental concern expressed here is reaching metals limits for land application of biosolids. Whether those same levels are of concern or not in bioretention media, or if we should be concerned earlier at lower levels, is an area open for discussion and investigation. More to the point, whatever the replacement cycle - let's say for the moment that bioretention systems require media replacement at 20 or even 25 years – what institutional system are we setting up to: 1. Define site failure 2. Assess when sites fail 3. Ensure media replacement happens when needed 4. Last but not least, if we lump bioretention and rain gardens together, what are the implications of having to remove and replace media in thousands of bioretention/rain garden systems 20 or so years down the line? Where will the used media be disposed?
pg 259	RE: "As stated previously, rainwater is usually slightly acidic (a pH of approximately 5.6 is typical)" There is no citation here' what is the source? We've located one source, albeit grey and dated (USGS 1997). According to this USGS site, western Washington rainfall is in the range of pH 5.1 to 5.3.

References

Ammann AA, Hoehn E, Koch S, 2003. Ground water pollution by roof runoff infiltration evidenced with multi-tracer experiments. Water Research 37, 1143-1153.

Bäckström M, Karlsson S, Bäckman L, Folkeson L, Lind B, 2004. Mobilisation of heavy metals by deicing salts in a roadside environment. Water Research 38, 720-732.

Bucheli TD, Müller SR, Heberle S, Schwarzenbach RP, 1998b. Occurrence and Behavior of Pesticides in Rainwater, Roof Runoff, and Artificial Stormwater Infiltration. Environmental Science & Technology 32, 3457-3464.

Bucheli TD, Müller SR, Voegelin A, Schwarzenbach RP, 1998a. Bituminous Roof Sealing Membranes as Major Sources of the Herbicide (R,S)-Mecoprop in Roof Runoff Waters: Potential Contamination of Groundwater and Surface Waters. Environmental Science & Technology 32, 3465-3471.

Chang M, McBroom MW, Scott Beasley R, 2004. Roofing as a source of nonpoint water pollution. Journal of Environmental Management 73, 307-315.

Clark SE, Long BV, Siu CYS, Spicher J, Steele KA, 2008a. Runoff Quality from Roofing during Early Life. Proceedings of the Water Environment Federation 2008a, 1048-1062.

Clark SE, Steele KA, Spicher J, Siu CYS, Lalor MM, Pitt R, Kirby JT, 2008b. Roofing Materials' Contributions to Storm-Water Runoff Pollution. Journal of Irrigation and Drainage Engineering 134, 638-645.

Cornell, 2007a. Cation Exchange Capacity (CEC), Agronomy Fact Sheet Series, Fact Sheet #22. Cornell University Cooperative Extension, Department of Crop and Soil Sciences, College of Agriculture and Life Sciences.

Cornell, 2007b. Estimating CEC from Cornell Soil Test Data, Agronomy Fact Sheet Series, Fact Sheet #23. Cornell University Cooperative Extension, Department of Crop and Soil Sciences, College of Agriculture and Life Sciences.

DeBusk KM, Hunt WF, 2009. Water Quality of Rooftop Runoff: Implications for Residential Water Harvesting Systetms, Urban Waterways, Ag-588-18W. North Carolina State University Cooperative Extension.

Dietz M, 2007. Low Impact Development Practices: A Review of Current Research and Recommendations for Future Directions. Water, Air, & Soil Pollution 186, 351-363.

Ellis JB, 2000. Infiltration Systems: A Sustainable Source-Control Option for Urban Stormwater Quality Management? Water and Environment Journal 14, 27-34.

Granato GE, Church PE, Stone VJ, 1995. Mobilization of major and trace constituents of highway runoff in groundwater potentially caused by deicing chemical migration, Transportation Research Record, pp. 92-104.

Hathhorn WE, Yonge D, Washington State Transportation Center (TRAC) WSU, Pullman, WA, 1995. The Assessment of Groundwater Pollution Potential Resulting From Stormwater Infiltration BMP's. Final Technical Report. Washington State Dept. of Transportation. Prepared for: Washington State Transportation Commission, Department of Transportation, and in cooperation with U.S. Department of Transportation Federal Highway Administration.

Howard JL, Sova JE, 1993. Sequential extraction analysis of lead in Michigan roadside soils: Mobilization in the vadose zone by deicing salts? Journal of Soil Contamination 2, 361-378.

Jassal RS, Black TA, Spittlehouse DL, Brümmer C, Nesic Z, 2009. Evapotranspiration and water use efficiency in different-aged Pacific Northwest Douglas-fir stands. Agricultural and Forest Meteorology 149, 1168-1178.

Keswick BH, Gerba CP, 1980. Viruses in groundwater. Environmental Science & Technology 14, 1290-1297.

Mason Y, Ammann AA, Ulrich A, Sigg L, 1999. Behavior of Heavy Metals, Nutrients, and Major Components during Roof Runoff Infiltration. Environmental Science & Technology 33, 1588-1597.

Mikula JB, Clark SE, Long BV, 2007. Evaluation and Verification of a Vadose Zone Model Applied to Stormwater Infiltration, in: Michael Clar E (Ed), Proceedings of the National Low Impact Development Conference. American Society of Civil Engineers, Wilmington, North Carolina, pp. pp 83 – 92.

Moore DR, Wondzell SM, 2005. Physical Hydrology and The Effects Of Forest Harvesting In The Pacific Northwest: A Review. JAWRA Journal of the American Water Resources Association 41, 763-784.

Nelson SS, Yonge DR, Barber ME, 2009. Effects of Road Salts on Heavy Metal Mobility in Two Eastern Washington Soils. Journal of Environmental Engineering 135, 505-510.

Nicholson N, Shirley E. Clark Ph.D. PE, D. WRE, Long BV, Siu CYS, Spicher J, Steele KA, 2010. Roof Runoff Water Quality - A comparison of traditional roofing materials. Proceedings of the World Environmental and Water Resources Congress 2010. World Environmental and Water Resources Congress 2010: Challenges of Change.

NOAA NCDC, 2008. Normal Monthly Precipitation (Inches), http://lwf.ncdc.noaa.gov/oa/climate/online/ccd/nrmlprcp.html.

Norrström AC, 2005. Metal mobility by de-icing salt from an infiltration trench for highway runoff. Applied Geochemistry 20, 1907-1919.

Norton D, Serdar D, Colton J, Jack R, Lester D, 2011. Control of Toxic Chemicals in Puget Sound: Assessment of Selected Toxic Chemicals in the Puget Sound Basin, 2007-2011, Pub. No. 11-03-055. Washington State Department of Ecology, Olympia, WA, p. 193 + app (295 total)

Oberts GL, Marsalek J, Viklander M, 2000. Review of Water Quality Impacts of Winter Operation of Urban Drainage. Water quality research journal of Canada 35, 781-808.

Roberts T, Serdar D, Maroncelli J, Davies H, 2011. Control of Toxic Chemicals in Puget Sound: Phase 3: Primary Sources of Selected Toxic Chemicals and Quantities Released in the Puget Sound Basin, Pub. No. 11-03-024. Washington State Department of Ecology, Olympia, WA, p. 202 + app (297 total)

Schueler T, 1994. Is Roof Runoff Really Clean? Technical Note 25. Watershed Protection Techniques 1, 54 - 55.

USGS, 1997. What is acid rain? http://pubs.usgs.gov/gip/acidrain/2.html, in: jmwatson@usgs.gov MbJW (Ed).

USGS, 2003. Ground-water, Surface-water and Precipitation Interactions Near Middle Dam, ME, http://me.water.usgs.gov/gwswpi.html.

Van Metre PC, Mahler BJ, 2003. The contribution of particles washed from rooftops to contaminant loading to urban streams. Chemosphere 52, 1727-1741.

Vialle C, 2011a. Hydraulic, physicochemical and microbiological study of a roof runoff harvesting system and environmental assessment, Laboratoire de Chimie Agro-Industrielle (LCA). Université de Toulouse.

Vialle C, Sablayrolles C, Lovera M, Jacob S, Huau MC, Montrejaud-Vignoles M, 2011b. Monitoring of water quality from roof runoff: Interpretation using multivariate analysis. Water Research 45, 3765-3775.

Zobrist J, Müller SR, Ammann A, Bucheli TD, Mottier V, Ochs M, Schoenenberger R, Eugster J, Boller M, 2000. Quality of roof runoff for groundwater infiltration. *Water Research* 34, 1455-1462.